

## **Fine Scale Baleen Whale Behavior Observed Via Tagging Over Daily Time Scales**

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### **LONG-TERM GOALS**

Tagging studies of cetaceans have focused primarily on two disparate time scales: short (hours) or long (weeks to months). Studies using sensor-rich suction-cup tags, focal follows, and proximate environmental sampling provide highly detailed observations of behavior that can be interpreted in the context of conspecific behavior, oceanographic conditions and prey distribution; however, tag attachment durations are typically short (hours) and sustained tracking and environmental sampling from small vessels is logistically challenging. Longer-term tagging studies using implanted satellite tags can provide location data over periods of weeks to months; however, inferences about behavior at time scales of hours to days are difficult to make with the limited sensor data returned by the tags and the low rate at which location data are provided (typically only 1-2 locations per day). While studies at both short and long time scales are enormously beneficial, there is also a critical need to understand cetacean behavior at intermediate daily time scales. Recent efforts to assess the impacts of sound on marine mammals and to estimate foraging efficiency have called for the need to measure daily activity budgets to quantify how much of each day an individual devotes to foraging, resting, traveling, or socializing. Moreover, many conservation issues require an understanding of daily diving activity (e.g., how much time each day does an individual spend near the bottom, at depth, in a sound channel, or at the surface?). Finally, several studies have observed diel trends in calling behavior or prey distribution that suggest diel variability in cetacean behavior; hypotheses about diel patterns in behavior can only be addressed definitively with tagging studies over daily time scales.

My long-term goal is to develop a tagging and tracking system that will allow cetaceans to be followed over time scales of days from an oceanographic vessel so that environmental sampling can be conducted in proximity to the tagged whale. Analyses of diving and movement behavior from the tagging and tracking data could then be combined with observations of oceanographic conditions and prey distribution to elucidate the environmental factors that influence both behavior and distribution over daily time scales.

## **OBJECTIVES**

My objectives are (1) to develop a reliable tagging and tracking system that allows sustained unambiguous tracking over time scales of days, and (2) to characterize the relationship between diel variability in the foraging behavior of baleen whales (North Atlantic right whales and sei whales) and the diel vertical migration behavior of their copepod prey. I hypothesize that (1) right whales track the diel vertical migration of copepods by feeding near the bottom during the day and at the surface at night, and (2) sei whales are unable to feed on copepods at depth during the day, and are therefore restricted to feeding on copepods at the surface only. Because copepod diel vertical migration is variable over time (days to weeks) and space (tens of kilometers) (Baumgartner et al. 2011), I further hypothesize that sei whales range much further than right whales to find areas where copepods are exhibiting weak diel vertical migration behavior.

## **APPROACH**

Most tracking studies rely on radio or acoustic transmitters incorporated in the animal-borne tag to provide a homing signal. Radio waves do not penetrate seawater, so opportunities to locate an animal carrying a radio transmitter are limited to very short periods when the animal is at the surface and the tag is exposed to air. Acoustic transmitters allow continuous tracking while an animal is submerged, but the reception range of a high-frequency transmitter (~30 kHz) is limited to 1-2 kilometers at most. While both of these tracking methods provide bearing from the tracking vessel to a tagged animal, neither provides accurate range measurements, so location estimation is ambiguous. In practice, these methods rely strongly on establishing visual contact with the tagged animal to verify its true location. Because visual contact requires daylight, these methods are far less effective during the night. Moreover, tracking via a homing signal is labor intensive and exhaustive, and is therefore difficult to maintain with great accuracy for tens of hours.

To accomplish sustained tracking over daily time scales, two innovations are required: (1) a reliable tag attachment that lasts for more than one day, and (2) an unambiguous tracking capability that does not rely on visual contact. For studies of baleen whale ecology, we have developed a dermal attachment that is implanted into the skin and blubber of a whale and acts as a short-term anchor for carrying tags for periods of hours to days (Baumgartner et al. 2015). We are combining this new attachment with a commercially available archival tag (MK10-PATF; Wildlife Computers) to allow real-time tracking via a FastLoc GPS receiver and an ARGOS radio transmitter integrated in the whale-borne tag. Every 5-15 minutes, FastLoc GPS data collected during the tagged whales' surfacings will be telemetered from the tag to a local ARGOS receiver aboard an oceanographic vessel where the whales' position will be calculated and displayed to allow both daytime and nighttime tracking (Figure 1). This precise tracking ability will allow the ship to continuously remain in proximity to the whale so that it can collect both behavioral, oceanographic, and prey observations.

## **WORK COMPLETED**

In May 2015, I participated in the annual NOAA NEFSC large whale cruise to the Great South Channel to tag right and sei whales with the new tag. Both the Bryant and the spicyTalk receivers were mounted on the high mast of the NOAA Ship Gordon Gunter, and both systems used BlackBox KVM extenders to route data to the ship's computer lab via Cat5e cables. To assist in finding whales, we had a DMON-equipped Slocum glider and a DMON-equipped wave glider doing passive acoustic surveys in the Great South Channel before and during the cruise. The gliders are capable of detecting

the calls of right, fin, sei, and humpback whales and transmitting the detection data to a shore-side server in near real time (see [dcs.who.edu](https://dcs.who.edu) for archived data). We were also assisted by the NOAA NEFSC aerial survey team who conducted several surveys of the Great South Channel before and during our cruise. Observers aboard the NOAA Ship Gordon Gunter also used 25× big-eye binoculars to search for large whales during the cruise, doing both broadscale surveys of the entire Great South Channel as well as small-scale surveys in the vicinity of the gliders when right/sei whale calls were acoustically detected.

Despite all of these efforts to find whales, we were unable to tag whales because of the very low abundance of right and sei whales. We spent a total of 21 days at sea, and we only deployed our small boat on one occasion to try to approach and tag a single whale. This was a great disappointment to me. This is the third failed cruise for this project: we had similarly low abundance of right and sei whales (and poor weather) during our cruise in May 2013, our May 2014 cruise was cancelled two days before it was scheduled to begin because of a rudder problem, and the May 2015 cruise saw very low abundance of right and sei whales again. I have worked in the Great South Channel since 2004 and I have never seen such low abundances of right and sei whales as I have in 2013 and 2015. We ended up conducting over 90 CTD/OPC/VPR casts during the cruise to try to characterize ocean conditions that may be contributing to the low right/sei whale abundance. These data will be compared to identical data collected in the 2000's to help understand why right/sei whale abundance is so low now.

I am scheduled to participate in the spring 2016 NOAA cruise to the Great South Channel during which I will try again to deploy the new tag.

## RESULTS

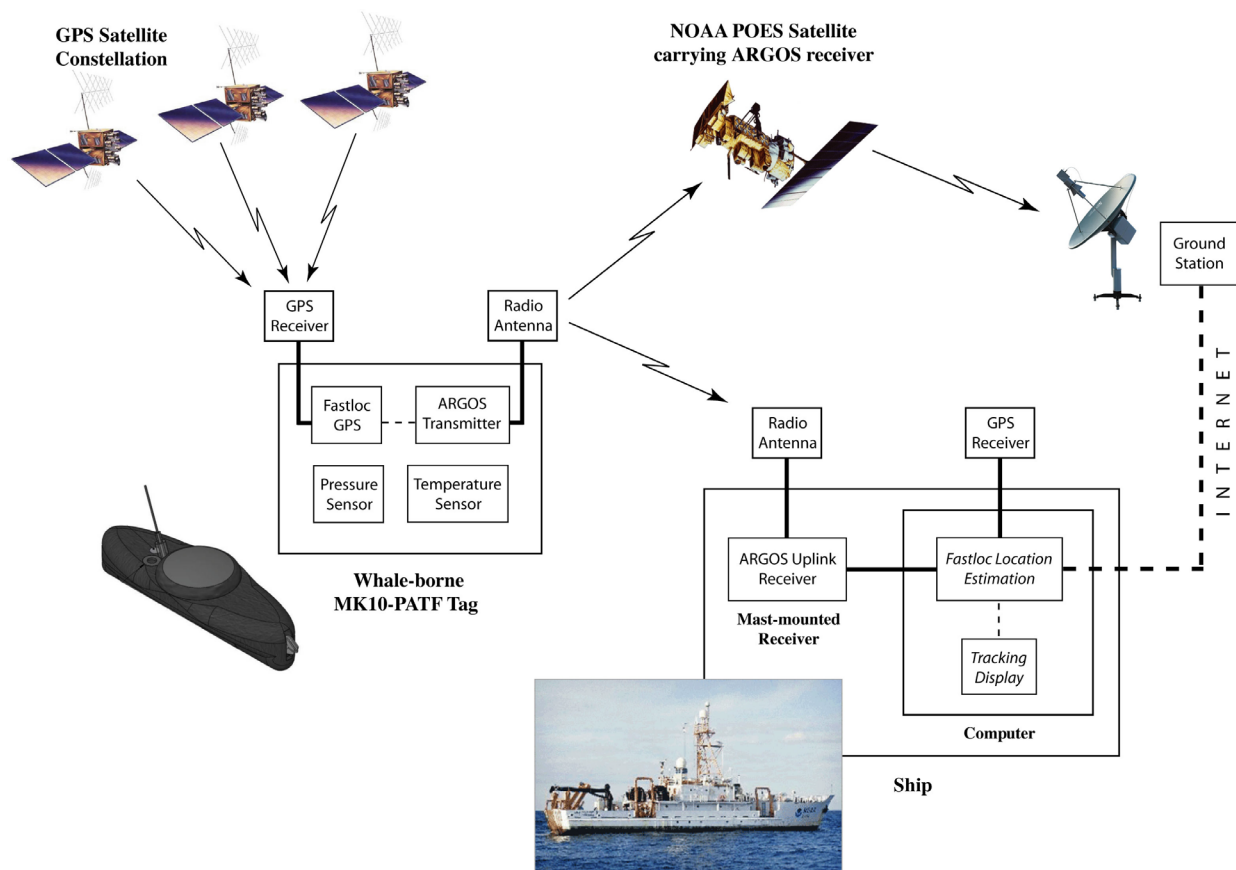
No scientific results are available at this time.

## IMPACT/APPLICATIONS

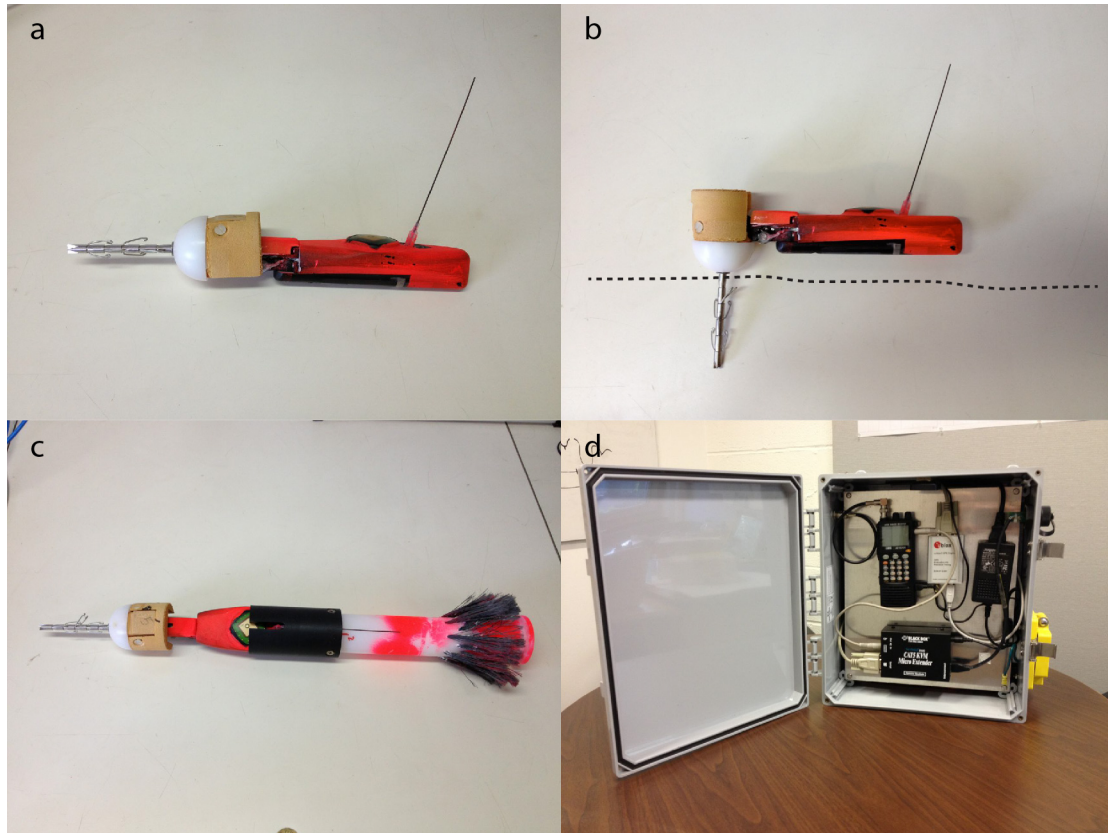
This work will directly help efforts to mitigate the effects of anthropogenic activities on baleen whales by characterizing (1) daily activity budgets, (2) where in the water column whales feed both day and night, and (3) the relationship between physical processes, prey distribution, and whale behavior. Ultimately, our ability to predict or even forecast whale distribution will hinge on a fundamental understanding of foraging behavior and how that behavior varies with changes in prey behavior and distribution.

## REFERENCES

- Baumgartner, M.F., T. Hammar, and J. Robbins. 2015. Development and assessment of a new dermal attachment for short-term tagging studies of baleen whales. *Methods in Ecology and Evolution* 6:289-297.
- Baumgartner, M.F., N.S.J. Lysiak, C. Schuman, J. Urban-Rich, and F.W. Wenzel. 2011. Diel vertical migration behavior of *Calanus finmarchicus* and its influence on right and sei whale occurrence. *Marine Ecology Progress Series* 423:167-184.



**Figure 1. Block diagram of tracking system based on whale-borne Wildlife Computers MK10-PATF tag and shipboard ARGOS receiving system. Fastloc GPS data is telemetered via an ARGOS transmitter from the tag to a local receiver mounted on a nearby ship's mast. The location of the tag is computed from the received Fastloc data and GPS satellite ephemeris data collected with a ship-mounted GPS receiver. In the unlikely event that the ARGOS transmissions from the tag cannot be received locally, Fastloc data from the tag can be acquired through the ARGOS system and relayed via the ship's Internet connection. All location data will be displayed on a chart on the ship's bridge to facilitate tracking.**



**Figure 2. (a) Modified MK10-PATF tag with attachment mechanism (including spring mechanism and dermal anchor with stainless steel pins) cocked for deployment in the compressed-air launcher. (b) Modified MK10-PATF tag with attachment mechanism in articulated position that would occur after attachment to a whale. Dashed line depicts the surface of the whale's skin; note that the tag is designed so that it does not contact the skin. (c) Tag with attached "carrier rocket" ready for loading into the compressed-air launcher (note flu-flu fletching at end of rocket to help the tag fly true in the air prior to attachment). (d) Weatherproof box containing wideband radio receiver, ublox GPS, power supply, and BlackBox KVM extender.**